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PATENT

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June 28, 2002
Date

Rena Iov

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants	:	Chee Peng Neo, Cher Khng Victor Tan, Kian Seng Ho and Hock Chuan Tan
Application No.	:	09/944,247 Confirmation No.: 1800
Filed	:	August 30, 2001
For	:	METHOD AND APPARATUS FOR DETECTING TOPOGRAPHICAL FEATURES OF MICROELECTRONIC SUBSTRATES

Docket No. : 108298548US

Date : June 28, 2002

Assistant Commissioner for Patents
Washington, DC 20231

TRANSMITTAL OF PRIORITY DOCUMENT

Sir:

Enclosed is a certified copy of Singapore Application No. 200104881-8 filed on August 13, 2001, upon which priority is based.

Respectfully submitted,
Perkins Coie LLP

John M. Wechkin
Registration No. 42,216

JMW:ri

Enclosure:
Certified Copy of Singapore Application No. 200104881-8

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REGISTRY OF PATENTS
SINGAPORE

This is to certify that the annexed is a true copy of the following Singapore patent application as filed in this Registry.

Date of Filing	:	13 AUGUST 2001
Application Number	:	200104881-8
Applicant(s)	:	MICRON TECHNOLOGY, INC.
Title of Invention	:	METHOD AND APPARATUS FOR DETECTING TOPOGRAPHICAL FEATURES OF MICROELECTRONIC SUBSTRATES

Sharmaine Wu Shee Mei
Assistant Registrar
for REGISTRAR OF PATENTS
SINGAPORE

PATENTS FORM 1

SINGAPORE
PATENTS ACT
(CHAPTER 221)
PATENTS RULES

Rule 19

13 AUG 2001

SP-1179

The Registrar
Registry of Patents

20010 4881-8

REQUEST FOR THE GRANT OF PATENT

THE GRANT OF A PATENT IS REQUESTED BY THE UNDERSIGNED ON THE BASIS OF THE PRESENT APPLICATION

I. Title of invention	METHOD AND APPARATUS FOR DETECTING TOPOGRAPHICAL FEATURES OF MICROELECTRONIC SUBSTRATES			
II. Applicant(s) *(See Note 2)*	*(a) Name*	MICRON TECHNOLOGY, INC.		
	Body Description/ Residency	A CORPORATION INCORPORATED IN DELAWARE, U.S.A		
	Street Name & Number	8000 SOUTH FEDERAL WAY P.O. BOX 6		
	City	BOISE		
	State	IDAHO 83706-9632		
	Country	UNITED STATES OF AMERICA		
	(b) Name	-		
	Body Description/ Residency	-		
	Street Name & Number	-		
	City	-		
	State	-		
	Country	-		
	(c) Name	-		
	Body Description/ Residency	-		
	Street Name & Number	-		
	City	-		
	State	-		
	Country	-		
III. Declaration of priority *(See note 3)*	*Country/Country Designated*	NONE	*File No.*	NONE
	Filing Date			
	Country/Country Designated		*File No.*	
	Filing Date			
	Country/Country Designated		*File No.*	
	Filing Date			

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IV. Inventors (See Note 4) (a) The applicant is/~~are~~ the sole/~~joint~~ inventor~~(s)~~.	☐ Yes		☒ No	
(b) A statement on Patents Form 8 is/~~will be~~ furnished	☒ Yes		☐ No	
V. Name of Agent (if any) (See Note 5)	HENRY GOH (S) PTE. LTD.			
VI. Address for Service (See note 6)	Block/Hse No.	-	Level No.	-
	Unit No./PO	183	Postal Code	913107
	Street Name	TOA PAYOH CENTRAL		
	Building Name	-		
VII. Claiming an earlier filing date under section 20(3), 26(6) or 47(4) (See note 7)	Application No.	-		
	Filing Date			
	[Please tick in the relevant space provided]: ( ) Proceeding under rule 27(1)(a). Date on which the earlier application was amended ________ Or ( ) Proceeding under rule 27(1)(b).			
VIII. Invention has been displayed at an International Exhibition	☐ Yes		☒ No	
IX. Section 114 requirements (See Note 9)	*The invention relates to and/or used a micro-organism deposited for the purposes of disclosure in accordance with Section 114 with a depositary authority under the Budapest Treaty*			
	☐ Yes		☒ No	

X. Check List (To be filled in by applicant or agent)			
	A. The application contains the following number of sheet(s):		
	1. Request	3	Sheets
	2. Description	14	Sheets
	3. Claim(s)	24	Sheets
	4. Drawing(s)	3	Sheets
	5. Abstract	1	Sheets
	B. The application as filed is accompanied by:		
	1. Priority document	-	
	2. Translation of priority document	-	
	3. Statement of inventorship & right to grant	X	
	4. International Exhibition Certificate	-	

XI. Signature(s) (See Note 10)		
	Applicant (a)	HGSR
	Date	13 AUGUST 2001
	Applicant (b)	
	Date	
	Applicant (c)	
	Date	

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Notes:

1. This form when completed, should be brought or sent to the Registry of Patents together with the prescribed fee and 3 copies of the description of the invention, and of any drawings.

2. Enter the **name and address of each applicant** in the spaces provided at paragraph II. **Names of individuals** should be indicated in full and the surname or family name should be underlined. **The names of all partners** in a firm must be given in full. **The place of residence of each individual** should also be furnished in the space provided. Bodies corporate should be designated by their **corporate name** and **country of incorporation** and, where appropriate, the **state of incorporation** within that country should be entered where provided. Where more than three applicants are to be named, the names and address of the fourth and any further applicants should be given on a **separate sheet** attached to this Form together with the **signature of each of these further applicants.**

3. The declaration of priority at paragraph III should state the date of the previous filing, the country in which it was made, and indicates the file number, if available. Where the application relied upon in an International Application or a regional patent application e.g. European patent application, one of the countries designated in that application [being one falling under the Patents (Convention Countries) Order] should be identified and the name of that country should be entered in the space provided.

4. Where the applicant or applicants is/are the sole inventor or the joint inventors, paragraph IV should be completed by marking the 'YES' Box in the declaration (a) and the 'NO' Box in the alternative statement (b). Where this is not the case, the 'NO' Box in declaration (a) should be marked and a statement will be required to be filed on Patents Form 8.

5. If the applicant has appointed an agent to act on his behalf, the agent's name should be indicated in the spaces available at paragraph V.

6. An address for service in Singapore to which all documents may be sent must be stated at paragraph VI. It is recommended that a telephone number be provided if an agent is not appointed.

7. When an application is made by virtue of section 20(3), 26(6) or 47(4), the appropriate section should be identified at paragraph VII and the number of the earlier application or any patent granted thereon identified. Applicants proceeding under section 26(6) should identify which provision in rule 27 they are proceeding under. If the applicants are proceeding under rule 27(1)(a), they should also indicate the date on which the earlier application was amended.

8. Where the applicant wishes an earlier disclosure of the invention by him at an International Exhibition to be disregarded in accordance with section 14(4)(c), then the 'YES' box at paragraph VIII should be marked. Otherwise the 'NO' box should be marked.

9. Where in disclosing the invention the application refers to one or more microorganisms deposited with a depository authority under the Budapest Treaty, then the 'YES' box at paragraph IX should be marked. Otherwise the 'NO' box should be marked.

10. Attention is drawn to rules 90 and 105 of the Patent Rules. Where there are more than three applicants, see also Note 2 above.

11. Applicants resident in Singapore are reminded that if the Registry of Patents considers than an application contains information the publication of which might be prejudicial to the defence of Singapore or the safety of the public, it may prohibit or restrict its publication or communication. Any person resident in Singapore and wishing to apply for patent protection in other countries must first obtain permission from the Singapore registry of Patents unless they have already applied for a patent for the same invention in Singapore. In the latter case, no application should be made overseas until at least two months after the application has been filed in Singapore.

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METHOD AND APPARATUS FOR DETECTING TOPOGRAPHICAL FEATURES OF MICROELECTRONIC SUBSTRATES

BACKGROUND

The present invention relates to methods and apparatuses for detecting topographical features of microelectronic substrates, for example, detecting the surface roughness of a microelectronic substrate having solder or gold bump terminals. Packaged microelectronic assemblies, such as memory chips and microprocessor chips, typically include a microelectronic substrate die encased in a plastic, ceramic, or metal protective covering. The dies are typically formed in or on a wafer, such as a silicon wafer, and can include functional devices or features, such as memory cells, processing circuits, and interconnecting wiring. Each die also typically includes bond pads or other conductive structures, such as gold bumps or solder bumps that are electrically coupled to the functional devices. The conductive structures can then be electrically coupled to pins or other types of terminals that extend outside the protective covering for connecting to buses, circuits, and/or other microelectronic assemblies.

One method for increasing the throughput of packaged microelectronic assemblies is to perform many processing operations on the dies before the dies are singulated from the wafer, a practice referred to in the industry as wafer-level packaging. One such process step includes disposing gold or solder bumps on the dies at the wafer level to form a "bumped" wafer. When performing such operations at the wafer level, it is typically important to measure the average thickness, thickness variation, and roughness of the wafer to ensure that the wafer meets tight dimensional specifications, and to ensure that any microdefects of the wafer (which can reduce wafer strength) are eliminated or reduced to acceptable levels.

Figure 1A is a schematic illustration of a conventional apparatus 10a for measuring the thickness and thickness variation of a wafer 30. Such apparatuses are available from ADE of Westwood, Massachusetts, under model numbers 9520 and 9530. The apparatus 10a can include a narrow, rod-shaped vacuum chuck 12 that supports the wafer 30, a lower capacitance probe 11a that measures the distance to the wafer back surface, and an upper capacitance probe 11b that measures the distance to the wafer front or device-side surface. The thickness of the wafer 30 at a particular point on the wafer can be calculated by subtracting the two distance measurements from the total distance between the capacitance probes 11a and 11b. The total thickness variation (TTV) of the wafer 30 can be calculated by traversing the rotating wafer 30 in between the probes 11a and 11b, determining a maximum thickness value and a minimum thickness value, and subtracting the minimum thickness value from the maximum thickness value. The average thickness of the wafer can be calculated by taking the mean of all the thickness values collected.

Figure 1B is a schematic illustration of an apparatus 10b used to determine the roughness of the wafer 30. The apparatus 10b can include a support table 20 that carries the wafer 30 with the back surface of the wafer 30 facing upwardly. A stylus 41 traverses over the back surface of the wafer 30 and moves up and down as it passes over roughness features on the back surface. A light 12 illuminates the back surface of the wafer 30 for visual inspection through a microscope 13 which can be used to capture a video image that can be saved on a bitmap file for correlating with the capacitance scan data. Such apparatuses are available from Veeco-Metrology Group of Santa Barbara, California.

One drawback with the devices 10a and 10b described above is that they may not be suitable for detecting the characteristics of bumped wafers which have solder bumps or gold bumps that project from a surface of the wafer. For example, the apparatus 10a shown in Figure 1A typically cannot distinguish between the surface of the wafer 30 and the elevated surface of the bumps on the wafer 30, and can accordingly produce erroneous thickness and thickness

variation measurements. The capacitance probes 11a and 11b typically do not have the high resolution required to determine surface roughness. The apparatus 10b shown in Figure 1B typically includes a vacuum system in the support table 20 to draw the wafer 30 tightly down against the table 20. When the wafer 30 includes solder bumps or gold bumps, the bumped surface of the wafer 30 may not form an adequate seal with the support table 20. Furthermore, the contact between the support table 20 and the wafer 30 can damage the bumps and render all or part of the wafer 30 inoperable.

Figure 1C illustrates a conventional apparatus 10c available from August Technology of Bloomington, Minnesota, and specifically configured to detect characteristics of a bumped wafer 30. The apparatus 10c can include a support table 20 having a vacuum system to draw the back surface of the wafer 30 down tightly against the support table 20, with the bumps 34 facing upwardly. A two-dimensional inspection camera 43 traverses above the device-side surface of the wafer 30 to assess the position, diameter, and/or surface characteristics of the bumps 34. A three-dimensional inspection camera 44 can traverse above the device-side surface of the wafer 30 to determine the height of the bumps 34.

One drawback with the device 10c shown in Figure 1c is that it is not configured to determine the thickness, the total thickness variation, or the roughness of the backside of the wafer 30. Accordingly, none of the apparatuses described above with reference to Figures 1A-C are capable of adequately determining the characteristics of the wafer 30 typically used to assess whether the wafer 30 is ready for singulation and subsequent packaging operations.

SUMMARY

The present invention is directed toward apparatuses and methods for detecting characteristics of a microelectronic substrate having a first surface with first topographical features and a second surface facing opposite from the first surface and having second topographical features. In one aspect of the invention, the apparatus can include a support member configured to carry the

microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed. The apparatus can further include a topographical feature detector positioned proximate to the support member and aligned with a first portion of the first surface of the microelectronic substrate when the microelectronic substrate is carried by the support member. The topographical feature detector can include a non-capacitive detection device configured to detect roughness characteristics of the first topographical features.

In a further aspect of the invention, the apparatus can also include a second topographical feature detector positioned proximate to the support member and configured to detect a characteristic of the second topographical features. The second topographical features can include solder bumps or gold bumps, and the first topographical features can include a roughness element that is not a conductive connection structure. The second topographical feature detector can include a probe having a contact portion configured to contact the microelectronic substrate, or a radiation emitter and receiver configured to direct radiation toward the microelectronic substrate and receive reflected radiation to detect a roughness of the microelectronic substrate. The radiation emitter can be configured to emit laser radiation, and the radiation receiver can be configured to receive laser radiation.

The invention is also directed toward a method for detecting characteristics of a microelectronic substrate having a first surface with first topographical features that do not include conductive connection structures, and a second surface facing opposite from the first surface and having second topographical features. The method can include supporting the microelectronic substrate while at least a first portion of the first surface is exposed and at least a second portion of the second surface is exposed. The method can further include detecting a characteristic of the first topographical features by positioning a topographical detection device at least proximate to the first portion of the first surface and activating the topographical detection device while the first portion of the first

surface and the second portion of the second surface are exposed to receive feedback from the first topographical features.

In a further aspect of the invention, the method can further include determining a thickness variation for the microelectronic substrate by establishing a reference plane, determining distances from the reference plane to a plurality of roughness features of the first surface, selecting from the determined distances a minimum distance value and a maximum distance value, and subtracting the minimum distance value from the maximum distance value. In yet a further aspect of the invention, the method for determining the thickness variation of the microelectronic substrate can be carried out on a computer.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1A-C are side views of apparatuses in accordance with the prior art showing selected components schematically.

Figure 2 is a side view of an apparatus in accordance with an embodiment of the invention showing selected components schematically.

Figure 3A is an enlarged side view of a portion of the apparatus shown in Figure 2.

Figure 3B is a flowchart illustrating a process for determining thickness variation for a microelectronic substrate with an embodiment of the apparatus shown in Figures 2 and 3A.

Figure 4 is an enlarged side view of a portion of an apparatus in accordance with another embodiment of the invention showing selected components schematically.

DETAILED DESCRIPTION

The following disclosure describes methods and apparatuses for detecting topographical features of microelectronic substrates. The term "microelectronic substrate" is used throughout to include substrates upon which and/or in which microelectronic circuits or components, data storage elements or layers, and/or

vias or conductive lines are or can be fabricated. Many specific details of certain embodiments of the invention are set forth in the following description and in Figures 2-4 to provide a thorough understanding of these embodiments. One skilled in the art, however, will understand that the present invention may have additional embodiments, and that the invention may be practiced without several of the details described below.

Figure 2 illustrates an apparatus 110 in accordance with an embodiment of the invention. In one aspect of this embodiment, the apparatus 110 can include a support member 120 that supports a microelectronic substrate 130. The microelectronic substrate 130 can have a first surface 131 with first topographical features 133 (such as roughness elements) and a second surface 132 facing opposite from the first surface 131 and having second topographical features 134. The second topographical features 134 can include solder bumps, gold bumps, or other electrical connection or termination structures that are offset from the second surface 132. The first topographical features can include roughness elements, but do not include solder bumps, gold bumps or other electrical connection or termination structures that are offset from the first surface 131. At least a portion of the first surface 131 can remain exposed for access by a first topographical feature detector 140a. At the same time, at least a portion of the second surface 132 can remain exposed for access by a second topographical feature detector 140b. Accordingly, the apparatus 110 can simultaneously detect characteristics of both the first topographical features 133 and the second topographical features 134 while the microelectronic substrate 130 is supported by the same support member 120.

In a further aspect of this embodiment, the support member 120 can have a peripheral contact surface 122 configured to contact a peripheral area of the first surface 131 of the microelectronic substrate 130 and an opening 121 under an interior portion of the first contact surface 131. The opening 121 can be an annular opening large enough to allow access to at least a representative portion of the first surface 131. The contact surface 122 can also extend radially inwardly

far enough to stably support the microelectronic substrate 130 without allowing the microelectronic substrate 130 to unduly sag or warp. The size of the peripheral region of the microelectronic substrate 130 engaged by the contact surface 122 can depend on factors such as the diameter of the substrate 130 and the thickness and/or rigidity of the substrate 130. In other embodiments, the support member 120 can engage only the peripheral edge of the microelectronic substrate 130, for example, with suction devices, clamps, and/or other retention elements configured to stably support the microelectronic substrate 130 in a flat orientation.

In one aspect of an embodiment shown in Figure 2, the support member 120 can include apertures 123 that extend through the contact surface 122. The apertures 123 can be in fluid communication with a chamber 124, and the chamber 124 can be coupled to a vacuum source 126 with a conduit 125. Accordingly, the vacuum source 126 can apply a vacuum to the vacuum apertures 123 to draw the microelectronic substrate 130 against the support member 120. The apertures 123 can also be coupled to a positive pressure source to separate the microelectronic substrate 130 from the support member 120. In other embodiments, the support member 120 can include other arrangements for securing the microelectronic substrate 130 during operation. An advantage of any of these embodiments is that the microelectronic substrate 130 can rest flat on the contact surface 122 while the topographical feature detectors 140a and 140b assess the topographical features 133 and 134, respectively.

The first topographical feature detector 140a can be positioned proximate to the exposed portion of the first surface 131, and the second topographical feature detector 140b positioned proximate to the exposed portion of the second surface 132. For example, the first topographical feature detector 140a can include a stylus or probe 141 that contacts the first surface 131 to detect differences in elevation between one first topographical feature 133 and another. Alternatively, the first topographical feature detector 140a can include other devices that also detect or assess characteristics of the first topographical

features 133 (for example, by receiving feedback from the first topographical features 133), as described below with reference to Figure 4.

The second topographical feature detector 140b can include a two-dimensional inspection camera 143 and/or a three-dimensional inspection camera 144. The two-dimensional inspection camera 143 can have a line-of-sight directed generally normal to the second surface 132 to detect the position, diameter, and/or surface features of the second topographical features 134. The surface features detected by the two-dimensional camera 143 can include the surface finish of the second topographical features 134, and/or whether adjacent topographical features 134 are inappropriately connected, for example with a solder bridge 136. The three-dimensional inspection camera 144 can have a line-of-sight directed obliquely toward the second surface 132, for example, to detect the height of the second topographical features 134 above the second surface 132. In other embodiments, the second topographical feature detector 140b can include other devices or arrangements.

In yet a further aspect of an embodiment of the apparatus 110 shown in Figure 2, the first topographical feature detector 140a can move over the first surface 131, as indicated by arrow "*A*." The second topographical feature detector 140b can move over the second surface 132 as indicated by arrow "*B*." The movement of the first topographical feature detector 140a can be coordinated with, or independent of, the movement of the second topographical feature detector 140b. The support member 120 can move the microelectronic substrate 130 relative to the topographical feature detectors 140a and 140b (as indicated by arrow "*C*") either in conjunction with, or in lieu of, moving the topographical feature detectors 140a and 140b. In any of the foregoing embodiments, the relative movement between the microelectronic substrate 130 and the topographical feature detectors 140a and 140b can be sufficient to obtain at least a representative sampling of the characteristics of the first topographical features 133 and the second topographical features 134, respectively.

Figure 3A is an enlarged view of a portion of the apparatus 110 and the microelectronic substrate 130 described above with reference to Figure 2. In one aspect of the embodiment shown in Figure 3A, the stylus 141 can include a stylus tip 145 that moves over the first surface 131 during operation. The first topographical features 133 of the first surface 131 can include a plurality of recesses 135 and projections 136. As the stylus tip 145 passes over the recesses 135 and projections 136, the first topographical feature detector 140a can detect, track and store measurements of the distance "*D*" between a reference plane 146 and the first surface 131. A plurality of distance measurements *D* can then be integrated or otherwise manipulated to define a roughness measurement of the first surface 131. For example, the calculated roughness can be an arithmetic roughness (Ra) determined by the following equation:

$$Ra = \frac{1}{l}\int_0^l \{f(x)\}dx$$

where l = representative length .

f(x) = function describing surface profile, with f(x) = 0 at its mean value

In one embodiment, the target range for *Ra* can be from about 13 microns to about 17 microns, and in other embodiments, the target range can have other values.

In one aspect of the foregoing embodiment, the stylus tip 145 can remain in contact with the first surface 131 of the microelectronic substrate 130 as the stylus 141 and the microelectronic substrate 130 move relative to each other. Alternatively, the stylus tip 145 can disengage from the first surface 131 when the stylus 141 and/or the microelectronic substrate 130 are moved, and re-engage when a new relative position is reached. In still a further alternate arrangement, the apparatus 110 can include a plurality of styli that simultaneously make individual distance measurements, reducing or eliminating the need to move the styli or the microelectronic substrate 130.

In one embodiment, the first topographical feature detector 140a can be used to determine a thickness variation for the microelectronic substrate using the information received from the stylus 141. Accordingly, the process can include tracking a minimum distance D_1 (corresponding to the distance between the reference plane 146 and the highest projection 136), and a maximum distance D_2 (corresponding to the distance between the reference plane 146 and the deepest recess 135). Assuming the microelectronic substrate 130 is positioned flat on the support member 120 (Figure 2) and the second surface 132 is flat, the total thickness variation (TTV) of the microelectronic substrate 130 can be computed subtracting D_1 from D_2. This method for determining TTV can be particularly useful when the processes used to form the microelectronic substrate 130 are reliable enough to produce substrates having a repeatable overall thickness value. In such instances, the apparatus 110 need only provide data on surface roughness and total thickness variation and need not detect or calculate the overall substrate thickness.

One or more of the foregoing process steps can be completed automatically by a computer program run on either the first topographical feature detector 140a or a computer coupled to the first topographical feature detector 140a. Referring now to Figure 3B, the process 300 can include receiving a plurality of measurements for distances between a reference plane and a corresponding plurality of topographical features of a microelectronic substrate (step 302). The process can further include selecting a minimum distance value from the plurality of distance values (step 304) and selecting a maximum distance value from the plurality of distance values (step 306). In step 308, the process can include determining a thickness variation value for the microelectronic substrate by subtracting the minimum distance value from the maximum distance value. The process can optionally include determining a roughness value for the microelectronic substrate, for example, by using any of a variety of known summation and/or integration techniques (step 310). The thickness variation

value and/or the roughness value can be output to a user in step 312, for example, via a visual digital display or a printed hard copy.

If the total thickness variation and/or roughness values determined for the first surface 131 are outside specified limits, the process used to remove material from the first surface 131 (for example, by backgrinding the first surface 131 with a Model DFG 850 backgrinder available from DISCO Corporation of Tokyo, Japan) can be modified. Accordingly, the next microelectronic substrate 130 (or batch of microelectronic substrates 130) can have the proper amount of material removed from it prior to being assessed by the apparatus 110.

One feature of the apparatus 110 described above with reference to Figures 2 and 3 is that the second surface 132 of the microelectronic substrate 130 is exposed while roughness and total thickness variation measurements are made on the first surface 131. Accordingly, the apparatus 110 can be less likely to damage the second topographical features 134, for example, when the second topographical features 134 include solder or gold bumps, or other protruding conductive elements.

Another advantage of this arrangement is that the apparatus 110 can simultaneously assess characteristics of the first surface 131 and the second surface 132. Accordingly, the overall time required to assess the characteristics of the microelectronic substrate 130 can be reduced because both processes can be carried out at the same time. As a result, the throughput for wafer-level packaging can be increased.

Yet another advantage of the foregoing arrangement is that the microelectronic substrate 130 can remain on the same support member 120 while both the first surface 131 and the second surface 132 are assessed. Accordingly, the microelectronic substrate 130 is less likely to become damaged as a result of moving the microelectronic substrate 130 from one support member to another.

Still another advantage of the foregoing arrangement is that the apparatus 110 can be used to monitor the quality of the backgrinding process. Accordingly, any discrepancies in the backgrinding process can be detected at an early stage

and corrected by additional backgrinding and/or by adjusting the backgrinding apparatus.

In other embodiments, the apparatus 110 can have other arrangements. For example, as shown in Figure 4, the first topographical feature detector 140a can include a non-contact detector 142 in addition to or in lieu of the stylus 141 described above with reference to Figures 2 and 3. In a further aspect of this embodiment, the non-contact detector 142 can issue emitted or incident radiation 147 (such as a laser beam) that strikes the first surface 131 of the microelectronic substrate 130 and returns as reflected radiation 148. The reflected radiation 148 is received by a sensor of the non-contact detector 142. The radiation emitted and received by the non-contact detector 142 can include visible laser radiation in one embodiment, and can include other types of visible or non-visible radiation in other embodiments. In still a further embodiment, the non-contact detector 142 can include a receiver (such as a camera) that detects radiation emitted by a separate source (such as a light source) and reflected by the first surface 131. In any of these embodiments, the non-contact detector 142 can be configured to interpret the reflected radiation 148 (for example, by comparison to a fixed reference plane) to determine the roughness characteristics of the first surface 131 and the total thickness variation of the microelectronic substrate 130.

In one embodiment, the non-contact detector 142 can be moved relative to the microelectronic substrate 130 to scan the emitted radiation 147 over the first surface 131. Alternatively, the microelectronic substrate 130 can be moved relative to the non-contact detector 142, or both the microelectronic substrate 130 and the non-contact detector 142 can be moved relative to each other. In still a further embodiment, the non-contact detector 142 can include a stationary device that receives (and optionally issues) a broad beam of radiation to detect a representative roughness and total thickness variation of the lower surface 131 without moving the microelectronic substrate 130. An advantage of this latter arrangement is that the time to determine the characteristics of the first surface

131 can be reduced because neither the microelectronic substrate 130 nor the non-contact detector 142 need be moved relative to each other.

In still a further embodiment, the apparatus 110 can be configured to include a stylus 141 that is interchangeable with a non-contact detector 142. For example, the stylus 141 (which can be a relatively inexpensive piece of equipment) can be used to detect the surface characteristics of a relatively thick microelectronic substrate 130, which is less likely to become damaged or warped as a result of contact with the stylus 141. The non-contact detector 142 (which is a relatively more expensive piece of equipment) can be used in place of the stylus 141 to detect the surface characteristics of relatively thin microelectronic substrates 130, which are more likely to become damaged by direct contact with the stylus 141.

In other embodiments, the apparatus 110 can have other arrangements. In one such embodiment, the apparatus 110 need not include the second topographical feature detector 140b, for example, when the characteristics of the second topographical features 134 are known to an adequate degree, or when it is not necessary to determine the characteristics of the second topographical features 134, or when these characteristics can be determined from another apparatus. In still further embodiments, the support member 120 can have arrangements other than the generally ring-shaped arrangement described above with reference to Figure 2. For example, the support member 120 can include a plurality of circumferentially spaced-apart support portions that together provide support for the microelectronic substrate 130. In yet further embodiments, the first topographical feature detector can include non-capacitive detection devices other than the stylus 141 and the radiation receiver and emitter described above, so long as the non-capacitive detection devices are configured to detect the surface roughness presented by features other than conductive terminal or connection structures (such as solder bumps or gold bumps).

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various

modifications may be made without deviating from the spirit and scope of the invention. Accordingly, the invention is not limited except as by the appended claims.

CLAIMS

I/we claim:

1 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with first topographical features and a second surface facing opposite from the first surface and having second topographical features, the apparatus comprising:

a support member configured to carry the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed; and

a topographical feature detector positioned proximate to the support member and aligned with the first portion of the first surface of the microelectronic substrate, the topographical feature detector including a non-capacitive detection device configured to detect roughness characteristics of the first surface when the microelectronic substrate is carried by the support member.

2 The apparatus of claim 1 wherein the topographical feature detector is configured to:

determine distances from a reference plane to a plurality of the first topographical features;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value.

3 The apparatus of claim 1 wherein the second topographical features include conductive structures protruding from the second surface, and wherein the topographical feature detector is a first topographical feature detector, and wherein the apparatus further comprises a second topographical feature detector

positioned proximate to the support member and configured to detect a characteristic of the second topographical features when the microelectronic substrate is supported by the support member.

4 The apparatus of claim 1 wherein at least one of the topographical feature detector and the support member is movable relative to the other while the microelectronic substrate is carried by the support member.

5 The apparatus of claim 1 wherein the topographical feature detector includes of a first system configured to detect roughness features of microelectronic substrates having a first range of thicknesses, the first system being interchangeable with a second system configured to detect roughness features of microelectronic substrates having a second range of thicknesses, with a maximum thickness of the second range being greater than a maximum thickness of the first range.

6 The apparatus of claim 1 wherein the second topographical feature includes a solder bump, and wherein the apparatus further comprises a raised feature detector positioned proximate to the support member and configured to detect a characteristic of the solder bump.

7 The apparatus of claim 1 wherein the second topographical feature includes a gold bump, and wherein the apparatus further comprises a feature detector positioned proximate to the support member and configured to detect a characteristic of the gold bump.

8 The apparatus of claim 1, further comprising:

a first camera positioned proximate to the support member and configured to detect at least one of a position, a surface defect and a bridge of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support member; and

a second camera positioned proximate to the support member and configured to detect a height of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support member.

9. The apparatus of claim 1 wherein the support member has a contact surface with a plurality of apertures, the apertures being coupleable to a vacuum source to draw the microelectronic substrate into contact with the support member.

10. The apparatus of claim 1 wherein the support member has a generally ring-shaped contact surface, and wherein the first portion of the first surface of the microelectronic substrate is disposed annularly inwardly from the contact surface when the support member carries the microelectronic substrate.

11. The apparatus of claim 1 wherein the topographical feature detector includes a probe having a contact portion configured to contact the microelectronic substrate, the topographical feature detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the microelectronic substrate.

12. The apparatus of claim 1 wherein the topographical feature detector includes a radiation receiver positioned to receive radiation reflected from the microelectronic substrate, the topographical feature detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the microelectronic substrate.

13. The apparatus of claim 1 wherein the topography detector includes a laser beam emitter positioned to direct radiation toward the microelectronic substrate, the topography detector further including a laser beam receiver positioned to receive radiation reflected from the microelectronic substrate, the topography detector being configured to detect a roughness of the microelectronic substrate

based on measurements at a plurality of locations on the microelectronic substrate.

14 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with first topographical features that do not include conductive connection structures, and a second surface facing opposite from the first surface and having second topographical features, the second topographical features including conductive structures protruding from the second surface, the apparatus comprising:

a support member configured to carry the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed; and

a topographical feature detector positioned proximate to the support member and aligned with the first portion of the first surface of the microelectronic substrate, the topographical feature detector including at least one of a contact probe and a radiation receiver positioned to detect characteristics of the first topographical features while the microelectronic substrate is carried by the support member without contacting the conductive structures protruding from the second portion of the second surface.

15 The apparatus of claim 14 wherein the topographical feature detector is configured to:

determine distances from a reference plane to a plurality of roughness features;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value.

16 The apparatus of claim 14 wherein the topographical feature detector is a first topographical feature detector, and wherein the apparatus further comprises

a second topographical feature detector positioned proximate to the support member and configured to detect a characteristic of the second topographical features when the microelectronic substrate is supported by the support member.

17. An apparatus for detecting characteristics of a microelectronic substrate having a first surface with first topographical features that do not include conductive connection structures, and a second surface facing opposite from the first surface and having second topographical features, the second topographical features including conductive structures protruding from the second surface, the apparatus comprising:

a support member configured to carry the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed;

a first topographical feature detector positioned proximate to the support member and aligned with the first portion of the first surface of the microelectronic substrate when the microelectronic substrate is carried by the support member to detect characteristics of the first topographical features, the first topographical feature detector including at least one of a contact probe positioned to contact the first surface and a radiation receiver positioned to receive radiation reflected from the first surface; and

a second topographical feature detector positioned proximate to the support member and aligned with the second portion of the second surface of the microelectronic substrate when the microelectronic substrate is carried by the support member to detect characteristics of the conductive structures protruding from the second surface.

18. The apparatus of claim 17 wherein the first topographical feature detector is configured to:

determine distances from a reference plane to a plurality of the first topographical features;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value to determine a thickness variation for the microelectronic substrate.

19 The apparatus of claim 17 wherein the first topographical feature detector includes a first system configured to detect roughness features of microelectronic substrates having a first range of thicknesses, interchangeable with a second system configured to detect roughness features of microelectronic substrates having a second range of thicknesses different than the first range of thicknesses.

20 The apparatus of claim 17 wherein the second topographical feature detector includes:

a first camera positioned proximate to the support member and configured to detect at least one of a position, a surface defect and a bridge of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support member; and

a second camera positioned proximate to the support member and configured to detect a height of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support member.

21 The apparatus of claim 17 wherein the support member has a contact surface with a plurality of apertures, the apertures being coupleable to a vacuum source to draw the microelectronic substrate into contact with the support member.

22 The apparatus of claim 17 wherein the support member has a generally ring-shaped contact surface, and wherein the first portion of the first surface is disposed annularly inwardly from the contact surface when the support member carries the microelectronic substrate.

23 The apparatus of claim 17 wherein the first topographical feature detector includes a probe having a contact portion configured to contact the microelectronic substrate, the first topographical feature detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the microelectronic substrate.

24 The apparatus of claim 17 wherein the first topographical feature detector includes a radiation emitter positioned to direct radiation toward the microelectronic substrate, the first topographical feature detector further including a radiation receiver positioned to receive radiation reflected from the microelectronic substrate, the first topographical feature detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the microelectronic substrate.

25 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having raised conductive features, the apparatus comprising:

a support member having a contact surface configured to contact the first surface of the microelectronic substrate, the support member being shaped to leave a first portion of the first surface exposed and a second portion of the second surface exposed when the microelectronic substrate contacts the support member;

a roughness detector that includes a probe having a contact portion configured to contact the microelectronic substrate, the roughness detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the first surface of the microelectronic substrate; and

an actuator coupled to at least one of the roughness detector and the support member to move at least one of the roughness detector and

the support member relative to the other while the support member supports the microelectronic substrate.

26 The apparatus of claim 25 wherein the contact surface has apertures coupleable to a vacuum source to draw the microelectronic substrate toward the support member.

27 The apparatus of claim 25 wherein the roughness detector is configured to:

determine distances from a reference plane to a plurality of the roughness features on the first surface of the microelectronic substrate;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value.

28 The apparatus of claim 25 wherein the roughness detector includes a first system configured to detect roughness features of microelectronic substrates having a first range of thicknesses, interchangeable with a second system configured to detect roughness features of microelectronic substrates having a second range of thicknesses different than the first range of thicknesses.

29 The apparatus of claim 25 wherein the raised conductive features include solder bumps and/or gold bumps, and wherein the apparatus further comprises a raised feature detector positioned proximate to the support member and configured to detect a characteristic of the solder bumps and/or gold bumps.

30 The apparatus of claim 25, further comprising:

a first camera positioned proximate to the support member and configured to detect at least one of a position, a surface defect and a bridge of at least one of the raised conductive features of the microelectronic substrate when the microelectronic substrate is supported by the support member; and

a second camera positioned proximate to the support member and configured to detect a height of at least one of the raised conductive features of the microelectronic substrate when the microelectronic substrate is supported by the support member.

31 The apparatus of claim 25 wherein the support member has a generally ring-shaped contact surface, and wherein the first portion of the first surface is disposed annularly inwardly from the contact surface when the support member carries the microelectronic substrate.

32 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having raised conductive features, the apparatus comprising:

a support member having a contact surface configured to contact the first surface of the microelectronic substrate, the support member being shaped to leave a first portion of the first surface and a second portion of the second surface exposed when the microelectronic substrate contacts the support member;

a roughness detector that includes a radiation receiver positioned to receive radiation reflected from the first surface of the microelectronic substrate, the roughness detector being configured to detect a roughness of the microelectronic substrate based on measurements at a plurality of locations on the first surface of the microelectronic substrate; and

an actuator coupled to at least one of the roughness detector and the support member to move at least one of the roughness detector and the support member relative to the other while the support member supports the microelectronic substrate.

33 The apparatus of claim 32 wherein the contact surface has apertures coupleable to a vacuum source to draw the microelectronic substrate into contact with the support member.

34 The apparatus of claim 32 wherein the roughness detector includes a radiation emitter is configured to emit laser radiation and a radiation receiver configured to receive laser radiation.

35 The apparatus of claim 32 wherein the roughness detector is configured to:

determine distances from a reference plane to a plurality of the roughness features on the first surface of the microelectronic substrate;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value.

36 The apparatus of claim 32, further comprising:

a first camera positioned proximate to the support member and configured to detect at least one of a position, a surface defect and a bridge of at least one of the raised conductive features of the microelectronic substrate when the microelectronic substrate is supported by the support member; and

a second camera positioned proximate to the support member and configured to detect a height of at least one of the raised conductive features of the microelectronic substrate when the microelectronic substrate is supported by the support member.

37 The apparatus of claim 32 wherein the support member has a generally ring-shaped contact surface, and wherein the first portion of the first surface is disposed annularly inwardly from the contact surface when the support member carries the microelectronic substrate.

38 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having raised conductive features, the apparatus comprising:

a generally ring-shaped support member;

a contact surface on the support member, the contact surface being configured to contact the first surface of the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed;

a roughness detector positioned proximate to the support member;

the roughness detector being and aligned with the first portion of the first surface of the microelectronic substrate when the microelectronic substrate is carried by the support member;

the roughness detector including at least one of a contact probe configured to contact the first surface, and a remote detector configured to receive radiation reflected from the first surface;

wherein at least one of the roughness detector and the support member is movable relative to the other while the microelectronic substrate is carried by the support member, and wherein the apparatus further comprises;

a first feature detector positioned proximate to the second surface of the microelectronic substrate to detect at least one of a diameter, position, and surface characteristic of the raised conductive features when the microelectronic substrate is carried by the support member; and

a second feature detector positioned proximate to the second surface of the microelectronic substrate to detect a height of the raised conductive features relative to the second surface when the microelectronic substrate is carried by the support member.

39 The apparatus of claim 38 wherein the raised conductive features include solder bumps and/or gold bumps, and wherein the first and second feature detectors are configured to detect characteristics of the solder bumps and/or gold bumps.

40 An apparatus for detecting characteristics of a microelectronic substrate having a first surface with first topographical features that include roughness elements, and a second surface facing opposite from the first surface and having second topographical features that include raised conductive structures, the apparatus comprising:

support means configured to carry the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed;

first topography detection means positioned proximate to the support member and aligned with the first portion of the first surface of the microelectronic substrate to detect at least one or a roughness and a thickness variation of the first surface when the microelectronic substrate is carried by the support member, the first topography detection means including at least one of a contact probe positioned to contact the first surface and a radiation receiver positioned to receive radiation reflected from the first surface; and

second topography detection means positioned proximate to the support member and aligned with the second portion of the second surface to detect a characteristic of the raised conductive structures when the microelectronic substrate is carried by the support means.

41 The apparatus of claim 40, further comprising actuator means operatively coupled to at least one of the first topography detection means and the support means to move at least one of the first topography detection means and the support means relative to the other while the microelectronic substrate is carried by the support means.

42 The apparatus of claim 40 wherein the first topography detection means is configured to:

determine distances from a reference plane to a plurality of roughness features of the microelectronic substrate;

select from the determined distances a minimum distance value;

select from the determined distances a maximum distance value; and

subtract the minimum distance value from the maximum distance value.

43 The apparatus of claim 40 wherein the first topography detection means includes a first system configured to detect roughness features of microelectronic substrates having a first range of thicknesses, interchangeable with a second system configured to detect roughness features of microelectronic substrates having a second range of thicknesses different than the first range of thicknesses.

44 The apparatus of claim 40 wherein the second topography detection means includes:

a first camera positioned proximate to the support means and configured to detect at least one of a position, a surface defect and a bridge of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support means; and

a second camera positioned proximate to the support means and configured to detect a height of at least one of the second topographical features of the microelectronic substrate when the microelectronic substrate is supported by the support means.

45 The apparatus of claim 38 wherein the support means has a contact surface with a plurality of apertures, the apertures being coupleable to a vacuum source to draw the microelectronic substrate into contact with the support member.

46 The apparatus of claim 38 wherein the support means has a generally ring-shaped contact surface, and wherein the first portion of the first surface is disposed annularly inwardly from the contact surface when the support member carries the microelectronic substrate.

47 The apparatus of claim 38 wherein the first topography detection means includes a probe having a contact portion configured to contact the first surface of the microelectronic substrate, the first topography detection means being configured to detect a roughness of the first surface based on measurements at a plurality of locations on the first surface.

48 The apparatus of claim 38 wherein the first topography detection means includes a radiation receiver positioned to receive radiation reflected from the first surface, the first topography detection means being configured to detect a roughness of the first surface based on measurements at a plurality of locations on the first surface.

49 A method for processing a microelectronic substrate, comprising:

forming first topographical features on or in a first surface of the microelectronic substrate, the first topographical features including roughness features but not including electrical connection structures offset from the first surface;

forming second topographical features on or in a second surface of the microelectronic substrate facing opposite from the first surface, the second topographical features including conductive structures protruding from the second surface;

supporting the microelectronic substrate while a first portion of the first surface is exposed and a second portion of the second surface is exposed; and

detecting a characteristic of the first topographical features by positioning a topographical detection device at least proximate to the first portion

of the first surface and activating the topographical detection device while the first portion of the first surface is exposed and while the second portion of the second surface is exposed with the conductive structures protruding from the second surface.

50 The method of claim 49 wherein detecting a characteristic of the first topographical features includes detecting a roughness of the first portion of the first surface by positioning a roughness detection device at least proximate to the first portion and activating the roughness detection device while the first portion of the first surface is exposed.

51 The method of claim 49 wherein detecting a characteristic of the first portion includes receiving radiation reflected from the first portion.

52 . The method of claim 49 wherein supporting the microelectronic substrate includes carrying the microelectronic substrate with a support member, and wherein the method further comprises detecting a characteristic of at least one of the second topographical features while carrying the microelectronic substrate with the support member.

53 The method of claim 49, further comprising moving at least one of the microelectronic substrate and the topographical detection device relative to the other while the first portion of the first surface is exposed.

54 The method of claim 49, further comprising determining a thickness variation for the microelectronic substrate by:

establishing a reference plane;

determining distances from the reference plane to a plurality of roughness features of the first surface;

selecting from the determined distances a minimum distance value;

selecting from the determined distances a maximum distance value; and

subtracting the minimum distance value from the maximum distance value.

55 The method of claim 49 wherein supporting the microelectronic substrate includes positioning the microelectronic substrate on a generally ring-shaped support surface with the first portion of the first surface positioned radially inward from the support surface.

56 The method of claim 49 wherein supporting the microelectronic substrate includes forcing the microelectronic substrate into contact with a support member.

57 The method of claim 47 wherein supporting the microelectronic substrate includes applying a vacuum to the microelectronic substrate to draw the microelectronic substrate into contact with a support member.

58 The method of claim 47, further comprising detecting at least one of a position, a surface defect, and a bridge of at least one of the second topographical features while supporting the microelectronic substrate with the first portion of the first surface exposed and the second portion of the second surface exposed.

59 The method of claim 49, further comprising detecting a height of at least one of the second topographical features of the microelectronic substrate while supporting the microelectronic substrate with the first portion of the first surface exposed and the second portion of the second surface exposed.

60 The method of claim 49, further comprising detecting a characteristic of at least one of the second topographical features by directing laser radiation toward the microelectronic substrate and receiving radiation reflected from the microelectronic substrate while the first portion of the first surface is exposed and the second portion of the second surface is exposed.

61 The method of claim 49, further comprising removing material from the first surface of the microelectronic before, after, or both before and after detecting a characteristic of the first topographical features.

62 The method of claim 49, further comprising:

removing a first portion of material from the first surface of the microelectronic substrate prior to detecting a characteristic of the first topographical features; and

removing a second portion of material from the first surface of the microelectronic substrate after detecting a characteristic of the first topographical features.

63 A method for detecting characteristics of a microelectronic substrate having a first surface with first topographical features that do not include conductive connection structures, and a second surface facing opposite from the first surface and having second topographical features, the method comprising:

supporting the microelectronic substrate while at least a first portion of the first surface is exposed and at least a second portion of the second surface is exposed; and

detecting a roughness of the first surface by positioning a topographical detection device at least proximate to the first topographical features of the first surface and activating the topographical detection device to receive feedback from the first topographical features while the first portion of the first surface and the second portion of the second surface are exposed.

64 The method of claim 63 wherein detecting a roughness of the first surface includes contacting a probe with the first portion of the first surface to determine a roughness of the first portion.

65 The method of claim 63 wherein detecting a roughness of the first surface includes receiving radiation reflected from the first portion.

66 The method of claim 63 wherein supporting the microelectronic substrate includes carrying the microelectronic substrate with a support member, and wherein the method further comprises detecting a characteristic of at least one of

the second topographical features while carrying the microelectronic substrate with the support member.

67 The method of claim 63, further comprising moving at least one of the microelectronic substrate and the topographical detection device relative to the other while the first portion of the first surface is exposed.

68 The method of claim 63, further comprising determining a thickness variation for the microelectronic substrate by:

establishing a reference plane;

determining distances from the reference plane to a plurality of roughness features of the first surface;

selecting from the determined distances a minimum distance value;

selecting from the determined distances a maximum distance value; and

subtracting the minimum distance value from the maximum distance value.

69 The method of claim 63 wherein supporting the microelectronic substrate includes positioning the microelectronic substrate on a generally ring-shaped support surface with the first portion of the first surface positioned radially inwardly from the support surface.

70 The method of claim 63 wherein supporting the microelectronic substrate includes forcing the microelectronic substrate into contact with a support member.

71 The method of claim 63 wherein supporting the microelectronic substrate includes applying a vacuum to the microelectronic substrate to draw the microelectronic substrate into contact with a support member.

72 The method of claim 63, further comprising detecting a characteristic of at least one of the second topographical features while supporting the microelectronic substrate with the first portion of the first surface exposed and the second portion of the second surface exposed.

73 The method of claim 63, further comprising detecting at least one of a position, a surface defect, and a bridge of at least one of the second topographical features while supporting the microelectronic substrate with the first portion of the first surface exposed and the second portion of the second surface exposed.

74 The method of claim 63, further comprising detecting a height of at least one of the second topographical features of the microelectronic substrate while supporting the microelectronic substrate with the first portion of the first surface exposed and the second portion of the second surface exposed.

75 The method of claim 63, further comprising detecting a characteristic of at least one of the second topographical features by directing laser radiation toward the microelectronic substrate and receiving radiation reflected from the microelectronic substrate while the first portion of the first surface is exposed and the second portion of the second surface is exposed.

76 The method of claim 63, further comprising removing material from the first surface of the microelectronic before, after, or both before and after detecting a characteristic of the first topographical features.

77 The method of claim 63, further comprising:

removing a first portion of material from the first surface of the microelectronic substrate prior to detecting a characteristic of the first topographical features; and

removing a second portion of material from the first surface of the microelectronic substrate after detecting a characteristic of the first topographical features.

78 A method in a computer for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface, the method comprising:

receiving a plurality of measurements for distances between a reference plane and a corresponding plurality of the roughness features of the first surface of the microelectronic substrate;

selecting a minimum distance value from the plurality of distance values;

selecting a maximum distance value from the plurality of distance values; and

determining a thickness variation for the microelectronic substrate by subtracting the minimum distance value from the maximum distance value.

79 The method of claim 78, further comprising determining a roughness value for the microelectronic substrate from the plurality of distance measurements.

80 The method of claim 78 wherein receiving the plurality of distance measurements includes receiving a plurality of distance measurements made by a probe that contacts the microelectronic substrate.

81 The method of claim 78 wherein receiving the plurality of distance measurements includes receiving a plurality of distance measurements from a device that receives radiation reflected from the microelectronic substrate.

82 A method for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having protruding conductive features, the method comprising:

supporting the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed; and

detecting a roughness of the first portion of the first surface by contacting a probe with the first portion and moving at least one of the probe and the microelectronic substrate relative to the other while the first

portion of the first surface is exposed and the second portion of the second surface is exposed.

83 The method of claim 82 wherein supporting the microelectronic substrate includes carrying the microelectronic substrate with a support member, and wherein the method further comprises detecting a characteristic of at least one of the protruding conductive features while carrying the microelectronic substrate with the support member.

84 The method of claim 82, further comprising determining a thickness variation for the microelectronic substrate by:

establishing a reference plane;

determining distances from the reference plane to a plurality of roughness features of the first surface;

selecting from the determined distances a minimum distance value;

selecting from the determined distances a maximum distance value; and

subtracting the minimum distance value from the maximum distance value.

85 The method of claim 82 wherein supporting the microelectronic substrate includes positioning the microelectronic substrate on a generally ring-shaped support surface with the first portion of the first surface positioned radially inwardly from the support surface.

86 The method of claim 82 wherein supporting the microelectronic substrate includes applying a vacuum to the microelectronic substrate to draw the microelectronic substrate into contact with a support member.

87 The method of claim 82, further comprising:

removing a first portion of material from the first surface of the microelectronic substrate prior to detecting a characteristic of the first topographical features; and

removing a second portion of material from the first surface of the microelectronic substrate after detecting a characteristic of the first topographical features.

88 A method for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having protruding conductive features, the method comprising:

supporting the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed; and

detecting a roughness of the first portion of the first surface by directing radiation toward the microelectronic substrate, receiving radiation reflected from the microelectronic substrate at a radiation receives, and moving at least one of the receiver and the microelectronic substrate relative to the other while the first portion of the first surface is exposed and the second portion of the second surface is exposed.

89 The method of claim 88 wherein supporting the microelectronic substrate includes carrying the microelectronic substrate with a support member, and wherein the method further comprises detecting a characteristic of at least one of the protruding conductive features while carrying the microelectronic substrate with the support member.

90 The method of claim 88, further comprising determining a thickness variation for the microelectronic substrate by:

establishing a reference plane;

determining distances from the reference plane to plurality of roughness features of the first surface;

selecting from the determined distances a minimum distance value;

selecting from the determined distances a maximum distance value; and

subtracting the minimum distance value from the maximum distance value.

91 The method of claim 88 wherein supporting the microelectronic substrate includes positioning the microelectronic substrate on a generally ring-shaped support surface with the first portion of the first surface positioned radially inwardly from the support surface.

92 The method of claim 88 wherein supporting the microelectronic substrate includes applying a vacuum to the microelectronic substrate to draw the microelectronic substrate into contact with a support member.

93 The method of claim 88, further comprising:

removing a first portion of material from the first surface of the microelectronic substrate prior to detecting a roughness of the first surface; and

removing a second portion of material from the first surface of the microelectronic substrate after detecting a roughness of the first surface.

94 A method for detecting characteristics of a microelectronic substrate having a first surface with roughness features and a second surface facing opposite from the first surface and having protruding conductive features, the method comprising:

supporting the microelectronic substrate by carrying the microelectronic substrate with a support member while a first portion of the first surface is exposed and a second portion of the second surface is exposed;

detecting a roughness of the first portion of the first surface by positioning a roughness detection device at least proximate to the first portion and moving at least one of the detection device and the microelectronic substrate relative to the other while the first portion

of the first surface is exposed and the second portion of the second surface is exposed; and

detecting a characteristic of at least one of the protruding conductive features while the microelectronic substrate is carried by the support member.

95 The method of claim 94, further comprising determining a thickness variation for the microelectronic substrate by:

establishing a reference plane;

determining distances from the reference plane to a plurality of roughness features of the first surface;

selecting from the determined distances a minimum distance value;

selecting from the determined distances a maximum distance value; and

subtracting the minimum distance value from the maximum distance value.

96 The method of claim 94, further comprising detecting a characteristic of at least one of the protruding conductive features with a camera while the first portion of the first surface is exposed and the second portion of the second surface is exposed.

97 The method of claim 94, further comprising:

removing a first portion of material from the first surface of the microelectronic substrate prior to detecting a roughness of the first surface; and

removing a second portion of material from the first surface of the microelectronic substrate after detecting a roughness of the first surface.

<u>METHOD AND APPARATUS FOR DETECTING TOPOGRAPHICAL FEATURES OF MICROELECTRONIC SUBSTRATES</u>

ABSTRACT OF THE DISCLOSURE

An apparatus and method for detecting characteristics of a microelectronic substrate. The microelectronic substrate can have a first surface with first topographical features, such as roughness elements, and a second surface facing opposite from the first surface and having second topographical features, such as protruding conductive structures. In one embodiment, the apparatus can include a support member configured to carry the microelectronic substrate with a first portion of the first surface exposed and a second portion of the second surface exposed. The apparatus can further include a topographical feature detector positioned proximate to support member and aligned with the first portion of the first surface of the microelectronic substrate to detect characteristics, such as a roughness, of the first surface while the microelectronic substrate is carried by the support member.

FIGURE 2

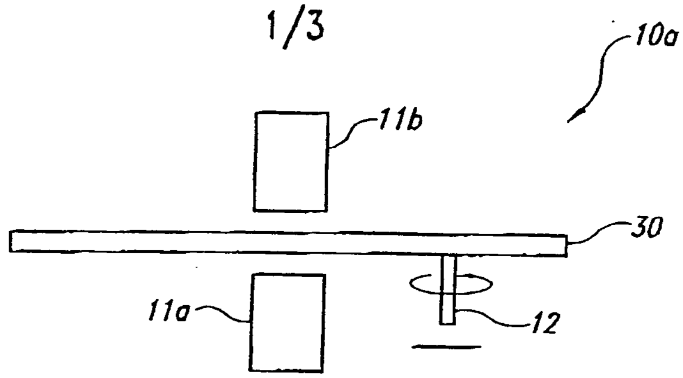


Fig. 1A
(Prior Art)

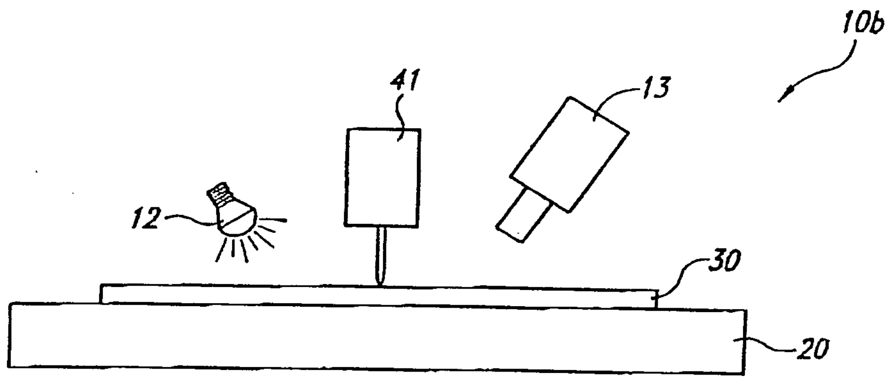


Fig. 1B
(Prior Art)

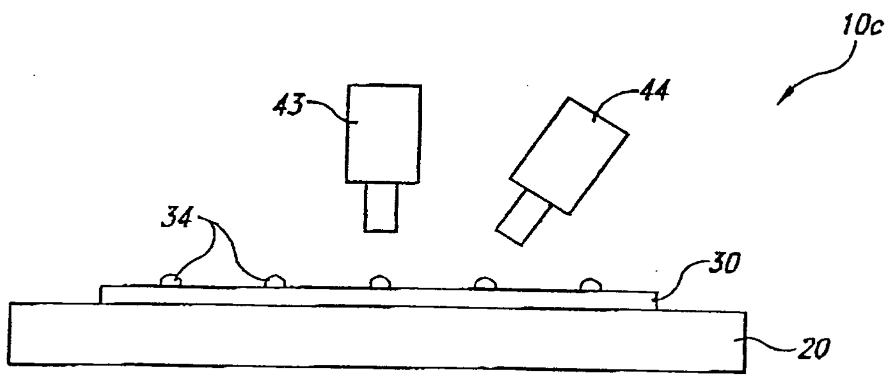


Fig. 1C
(Prior Art)

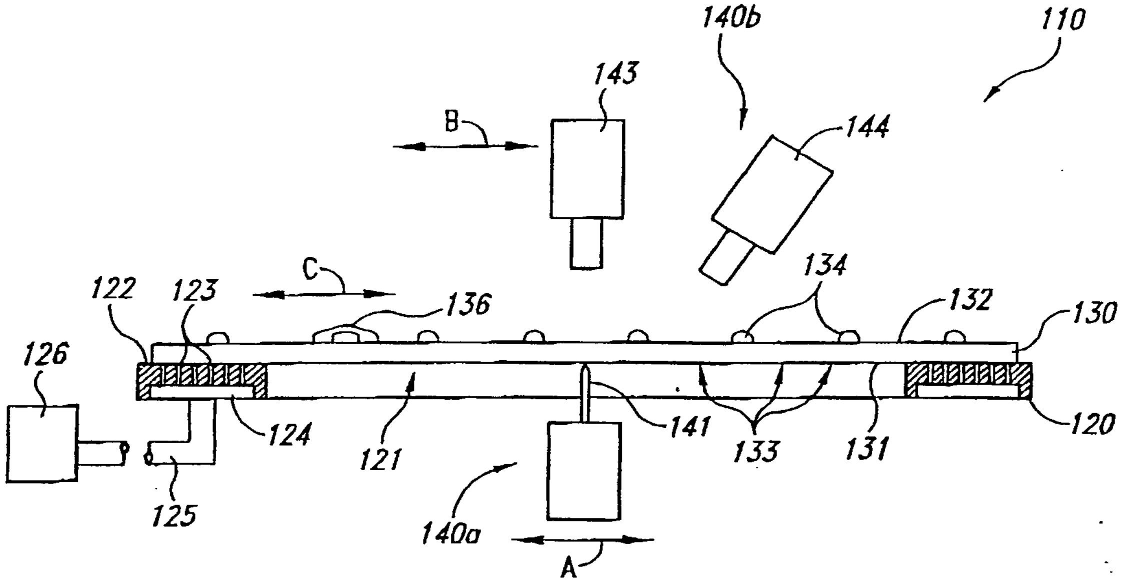

140b
110
143
B
144
134
C
132
122
123
136
130
126
124
141
120
121
133
131
125
140a
A

Fig. 2

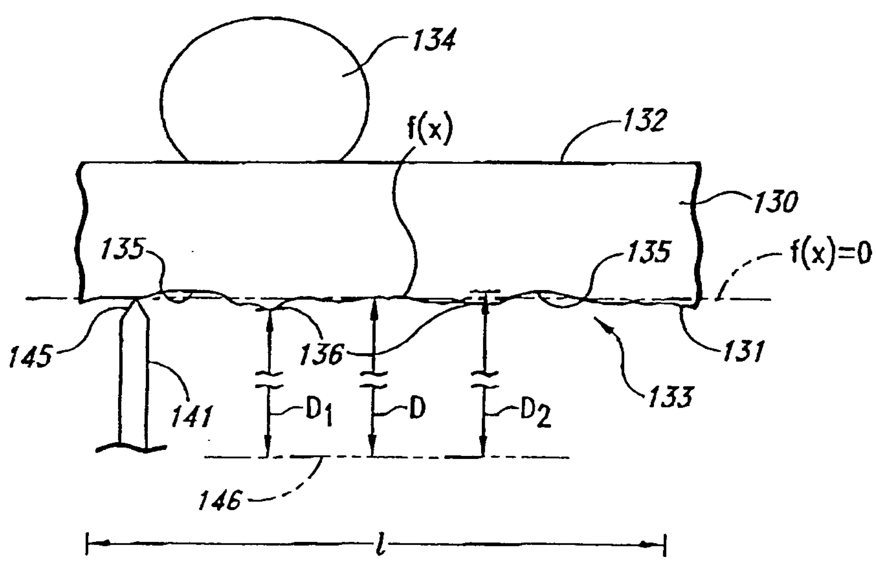

134
f(x)
132
130
135
135
f(x)=0
145
136
131
133
141
D_1
D
D_2
146
l

Fig. 3A

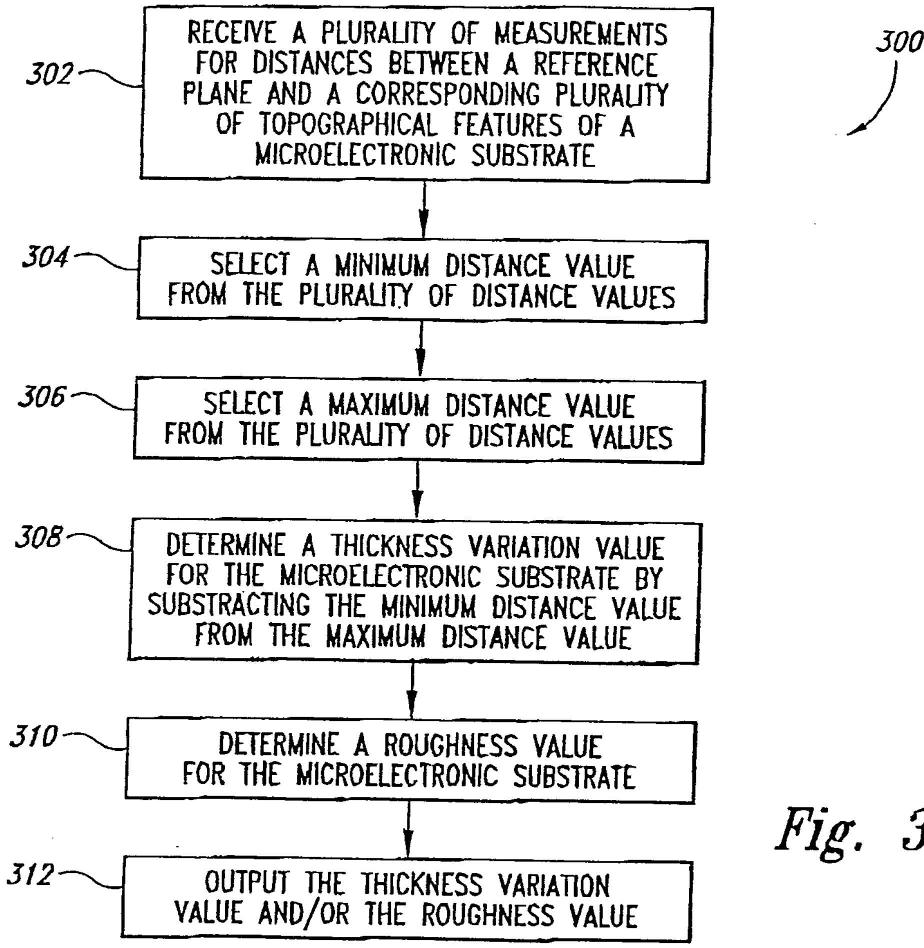
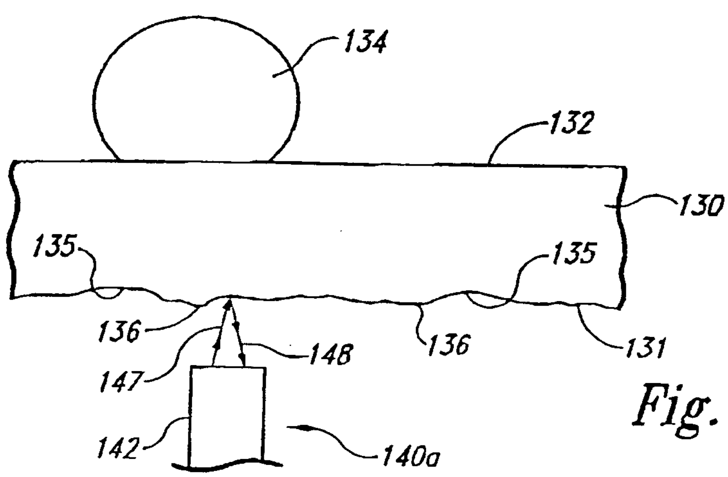

300
302
RECEIVE A PLURALITY OF MEASUREMENTS FOR DISTANCES BETWEEN A REFERENCE PLANE AND A CORRESPONDING PLURALITY OF TOPOGRAPHICAL FEATURES OF A MICROELECTRONIC SUBSTRATE
304
SELECT A MINIMUM DISTANCE VALUE FROM THE PLURALITY OF DISTANCE VALUES
306
SELECT A MAXIMUM DISTANCE VALUE FROM THE PLURALITY OF DISTANCE VALUES
308
DETERMINE A THICKNESS VARIATION VALUE FOR THE MICROELECTRONIC SUBSTRATE BY SUBSTRACTING THE MINIMUM DISTANCE VALUE FROM THE MAXIMUM DISTANCE VALUE
310
DETERMINE A ROUGHNESS VALUE FOR THE MICROELECTRONIC SUBSTRATE
312
OUTPUT THE THICKNESS VARIATION VALUE AND/OR THE ROUGHNESS VALUE

Fig. 3B


134
132
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140a

Fig. 4